2007

2007 Program and Abstracts

University of Dayton. Department of Mathematics

Undergraduate Mathematics Day at the University of Dayton

November 3, 2007

PROGRAM

8:45 - 9:30	Check-in, folder pick-up, refreshments	Science Center Auditorium Lobby
9:30 - 9:45	Welcome: Paul Benson Dean College of Arts and Sciences	O'Leary Auditorium
9:45 - 10:45	Invited Address: Colleen Hoover St. Mary's College Garden-variety Symmetry	O'Leary Auditorium
11:00 - 11:55	Contributed Paper Sessions (Part I)	Science Center
12:00 - 1:00	Lunch	Main Meeting Room, Virginia W. Kettering Hall
1:15 - 2:25	The Eighth Annual Kenneth C. Schraut Memorial Lecture: William Dunham Muhlenberg College An Euler Trifecta	O'Leary Auditorium
2:25 - 2:55	Break with Refreshments	Science Center Auditorium Lobby
2:55 - 4:10	Contributed Paper Sessions (Part II)	Science Center
4:15 - 5:05	Panel discussion on summer research experiences for undergraduate students	Science Center Auditorium

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Schedule for Contributed Paper Sessions, Part I:

	Science Center Auditorium (SC 114)	Science Center 146	Science Center 216	Science Center 224	Science Center 323
11:00 - 11:15	Jonathan Beagley Illinois Institute of Technology Minimum Semi-Definite Rank of Graphs with 2-Vertex Cut Sets	Shawn Ryan University of Akron A Buckling Problem for Graphene Sheets	Rob Denomme Ohio State University Elliptic Curve Primality Tests for Fermat and Related Primes	Evan Hartman University of Dayton Random Walks on Z	Elizabeth Freshley Otterbein College The Formula $\int_a^b f(x)dx = F(b) - F(a)$

					Should Be Revised
11:20 - 11:35	Kevin Ventullo Illinois Institute of Technology Silver Cubes	Erin Shafer University of Dayton Property Distributions and Blending Predictions of JP-8 Fuel	Joshua Craven University of Dayton How to Have a Coin Toss Over the Phone	Kerry McIver John Carroll University The Perfect Shuffle	Robert Deis Jacquline Nunner Carroll High School There Are Just Not Enough Daylight Hours in a Day!
11:40 - 11:55	Rachel Grotheer Denison University The Complete Story of Stick Knots in K_7	Karl Hess Sinclair Community College An Application of Analytic Geometry to Designing Machine Parts – and Dresses	Jenita Levine University of Dayton Who Has All the Gold Coins?	Emily Wheeler University of Dayton The Connection Between Similarity and Right Triangle Trigonometry	Dakkak Abdulmajed University of Toledo Solving Partial Differential Equations with Dirichlet Boundary Conditions on the Disk and Finding Their Bifurcation Points

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Schedule for Contributed Paper Sessions, Part II:

	Science Center Auditorium (SC 114)	Science Center 146	Science Center 216	Science Center 224	Science Center 323
2:55 - 3:10	Ciara Dillon Ohio Dominican University The MicroRNA Genome in Diffuse Large B-cell Lymphoma	Nicholas Armenoff University of Dayton Reachability of Positions in a Chip Firing Game	Allison Horney Taylor Lowry Fairmont High School A New Spin on Baseball!	Victor Velten University of Dayton The Mathematics Behind the Finite Element Method	Shelley Leber University of Dayton Mean of Real Numbers
3:15 - 3:30	Philip Pfeiffer University of Dayton Determining the Statistical Significance of Observed Frequencies of Short DNA Motifs in a Genome	Gwen Harpring Erin Lambka University of Dayton The Pythagorean Theorem	Kyle Kremer Joe Plattenburg Fairmont High School Breaking the Curve	Sarah Huggins University of Dayton An Everywhere Continuous but Nowhere Differentiable Function	Danielle Carleton University of Dayton The Fibonacci Sequence and Golden Numbers
3:35 - 3:50	David Aaby University of Dayton Bacteriophage Biomathematics	Michelle Brasdovich Katie Puthoff University of Dayton The Area of a Circle and the History of π	Jinyang Sun University of Dayton A Basic Building Block in Life Insurance--Time-Until-Death Random Variable *T(x)*	Edward Timko University of Dayton Conditional Convergence of Integrals in Analogy to Series	Anne Rollick John Carroll University The Mordell-Weil Group of the Elliptic Curves $y^2 = (1-x^2)(1-k^2x^2)$
3:55 - 4:10	Casey Hanley University of Dayton A River Continuum Analysis Of Relationships Between Land Use, Spatial Scale, And Macroinvertebrate Assemblages Of The Little Miami River, Ohio	Brandon Weislak Xavier University Euler: Harmonious Mathematics	Harrison Potter Marietta College Pricing the Asian Call Option	Jeffrey Neugebauer University of Dayton Boundedness Properties of Solutions of Nonlinear Volterra Integral Equations	

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Abstracts:

(Listed in alphabetical order by presenter. If a paper has multiple authors, the presenters are marked with *)

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David Aaby, University of Dayton
Bacteriophage Biomathematics
Bacteriophage are viruses that attack bacteria. They are the most abundant biological entity in the world, yet we know very little about them. One of the goals in studying bacteriophage is to create a phylogenetic tree. Phylogeny is the study of evolutionary relatedness among various groups of organisms. Because bacteriophage are unique and numerous, the current phylogenetic techniques do not work. We developed a new process that finds importance ranking for bacteriophage proteins and creates evolutionary distances between them in order to construct a phylogenetic tree. Using category theory, we seek to justify this new process for determining the phylogeny of bacteriophage.

Dakkak Abdulmajed, University of Toledo
Solving Partial Differential Equations with Dirichlet Boundary Conditions on the Disk and Finding Their Bifurcation Points
We present our research where we solved a certain class of partial differential equations under the Dirichlet boundary condition on the disk region. We present relevant concepts from differential equations, algebra, and graph theory to find solutions to equations of the form $\Delta u + \mathrm{su} = 0$, where Δ is the Laplacian operator, effectively. Two main algorithms used to find the bifurcation points will be presented: tangent Galerkin Newton algorithm (GNGA) and cylindrical GNGA, along with the significance of these bifurcation points.

Nicholas Armenoff, University of Dayton
Reachability of Positions in a Chip Firing Game
We consider mathematical models of the game Mancala. Let D be a directed graph with a number of chips on each vertex. A move can be made if a vertex in the vertex set of D has at least as many chips as its outdegree, in which case a chip on the vertex is sent along each edge to the adjacent verticies. Given two game states, we ask if there is a sequence of moves which will transform the first game state to the second game state. To answer this question, we use related algebraic concepts.

Jonathan Beagley, Illinois Institute of Technology
Minimum Semi-Definite Rank of Graphs with 2-Vertex Cut Sets
The minimum semidefinite rank (MSR) of a graph, G, is defined to be min{rank(A), for all A in P(G)}, where P(G) is the set of positive semi-definite matrices with corresponding graph G. New results in this topic will be described, and a catalogue of graphs with known MSRs will be discussed.

Michelle Brasdovich* and Katie Puthoff*, University of Dayton
The Area of a Circle and the History of π
We will discuss the influence of the Egyptians and Archimedes on the concept of the area of the circle and the history of π.

Danielle Carleton, University of Dayton
The Fibonacci Sequence and Golden Numbers
The Fibonacci sequence has been around for over 1,000 years, and many interesting properties of this sequence are known. We will define the sequence and prove some of its basic properties. We will establish a connection between the Fibonacci sequence and the golden numbers, famous for their use in Greek art and architecture. We will also discuss the continued fraction of Bombelli.

Joshua Craven, University of Dayton
How to Have a Coin Toss Over the Phone
Have you ever been talking with someone on the phone and wanted to decide something over a coin toss? If you tried, the person who did not flip the coin would never be completely satisfied that the person flipping the coin did not cheat. Here is an interesting application of number theory that works just like a coin toss and will also leave both parties satisfied that no one cheated.

Robert Deis* and Jacquline Nunner*, Carroll High School
There are Just Not Enough Daylight Hours in a Day!
Does it seem like days get short really fast at the beginning of Autumn? Does it seem like during the winter it takes a long time for days to gain daylight, and when spring finally comes, we gain daylight rapidly? How about those long days of summer? There seems to be a long period of summer when daylight is plentiful? These are questions that can be answered with a little curve fitting and a lot of calculus. This talk will summarize an in-class, progressive project for introducing calculus concepts including the concepts of rate of change, derivatives of trigonometric functions, maxima and minima, and points of inflection.

Rob Denomme, Ohio State University
Elliptic Curve Primality Tests for Fermat and Related Primes
Proofs of three new primality tests for Fermat and associated primes will be discussed. The tests are very similar to the well known Lucas-Lehmer test, and the proofs are based on the simple Pepin's test. The twist is that the tests utilize elliptic curves by manipulating their defect and introducing an interesting *Z[i]* module structure.

Ciara Dillon*, Ohio Dominican University, and Ricardo Aguiar
The MicroRNA Genome in Diffuse Large B-cell Lymphoma
MicroRNAs (miRNAs) are small non-protein coding RNAs that attenuate gene expression by pairing to the 3'UTR of target transcripts inducing RNA cleavage or translational inhibition. This novel class of genes is believed to regulate the expression of about one third of the human genome. Expectedly therefore, a critical role for miRNAs in several physiologic and pathological processes, including cancer, has been recently uncovered. However, the role of miRNAs in the most common type of lymphoid malignancies in adults, diffuse large B-cell lymphoma (DLBCL), has not been studied. To address this issue, we designed and implemented a tiling array CGH platform that defines the structural integrity of all human miRNAs in a single assay. Using this tool we analyzed a large series of 85 well characterized DLBCLs and found disruption of at least one miRNA locus in 95% of tumors. This data suggests that miRNAs may play a role in the pathogenesis of DLBCL.

Elizabeth Freshley* and Zengxiang Tong, Otterbein College

The Formula $\int_a^b f(x)dx = F(b) - F(a)$ Should Be Revised

The above formula is in James Stewart's book Calculus. The author presents it as follows: If *f* is continuous on [a, b], then $\int_a^b f(x)dx = F(b) - F(a)$ where *F* is any antiderivative of *f*, that is $F'(x) = f(x)$. Almost all calculus textbooks adopt this formula as a classic expression of the second part of the FTC. However, we think this formula has a flaw. The conditions in the statement of the theorem do not guarantee that *F*(*x*) is defined at the endpoints of the interval [*a*, *b*]. We will provide an example to show the difficulty that arises in that case. We will further provide a formula that not only takes care of the difficulties at the endpoints but also provides a natural connection between the indefinite integral and the definite integral, and between proper and improper definite integrals.

Rachel Grotheer, Denison University
The Complete Story of Stick Knots in K_7

In 1983, Conway and Gordon, and Sachs showed the complete graph on 7 vertices is intrinsically knotted – every embedding contains at least one knot. Recently, molecular chemists have constructed knotted molecules in hopes that they possess unique and useful properties. Results regarding these types of knots are of particular interest to their work. In this original work, we extend the results of Conway, Gordon and Sachs by finding the frequency of knots in all straight-edge embeddings of the complete graph on seven vertices where all the vertices lie on the convex hull. For each embedding, there are 360 Hamiltonian cycles that could possibly be knotted. Given any embedding, we can distinguish the number and types of knots present. It was shown in 1983 that there exists an embedding of the complete graph on six vertices that has no knots. We will show how the addition of one vertex and its incident edges creates an embedding of the complete graph on seven vertices that has exactly one knot.

Casey Hanley*, M. Eric Benbow, Albert J. Burky, Muhtadi M. Islam, Megan E. Shoda, Douglas A. Vonderhaar, University of Dayton
A River Continuum Analysis Of Relationships Between Land Use, Spatial Scale, And Macroinvertebrate Assemblages Of The Little Miami River, Ohio

Maintaining biodiversity in the face of encroaching human disturbance has received much attention in recent years. Relationships between in-stream habitat quality and the surrounding terrestrial realm may serve as practical predictive models for restoration efforts. Water quality data and six quantitative macroinvertebrate samples representing thirteen sites along the Little Miami River in southwestern Ohio were collected in June/July 2007. A suite of five macroinvertebrate indices was calculated for each sample. Land cover was characterized for each site at five spatial scales ranging from the entire catchment to local riparian segments. Catchments for each site were delineated using ArcMap 6.0 software. Bivariate regression analysis was used to compare macroinvertebrate indices to land use practices at the three riparian zone spatial scales. In general, significant correlations were found at the 1000M and 200M riparian buffer segments with correlation coefficients increasing as spatial scale decreased indicating local land use effects are the best predictor of in-stream conditions. These results suggest restoration efforts should focus on local scale riparian corridor characteristics to achieve highest habitat quality.

Gwen Harpring* and Erin Lambka*, University of Dayton
The Pythagorean Theorem

We will present a brief history on Pythagoras and his theorem and show two proofs of the Pythagorean Theorem.

Evan Hartman, University of Dayton
Random Walks on Z

A random walk is a formalization of the intuitive concept of taking successive steps (or events), each in a random direction. We will introduce the concept of random walks by focusing on a probabilistic interpretation of a one-dimensional random walk on Z. We will show an application to a simplified gambling game and consider questions such as "What is the probability of finishing with a certain score?" and "What is the probability of achieving a certain score and finishing with a certain score?"

Karl Hess, Sinclair Community College
An Application of Analytic Geometry to Designing Machine Parts – and Dresses

This talk will address a problem in machine design that an engineer asked the speaker to solve. The problem involves creating a flat pattern for a tubular machine part. A three-dimensional coordinate system will be used, but anyone with a solid understanding of trigonometry should be able to follow the solution. The speaker will also reveal an unexpected connection to another design problem.

Allison Horney*, Taylor Lowry*, Eric Schwenker, Evan Wray, Fairmont High School
A New Spin on Baseball!

All baseball fans know what a curveball is physically; but what is a curveball mathematically, and how does it differ from a fastball? The secret of a pitch lies in its spin. In this talk we will define the spin of a baseball and investigate the effects of its magnitude and direction by using data collected by MLB.com Gameday™ from the league's best pitchers. We will then use this model to differentiate between the spin of a curveball and that of a fastball.

Sarah Huggins, University of Dayton
An Everywhere Continuous but Nowhere Differentiable Function

It is commonly understood that differentiable functions are continuous. There are, however, functions that are continuous everywhere but not differentiable at certain points, such as the absolute value function, which is continuous but not differentiable at zero. This paper explores the possibility of a function that is continuous but not differentiable anywhere. In 1872, Karl Weierstrass found such a function, and we will affirm his conclusions by finding a similar function that is everywhere continuous but nowhere differentiable.

Kyle Kremer*, Joe Plattenburg*, Amanda Dahlman, Jesse DePinto, Fairmont High School
Breaking the Curve

Imagine you are up to bat in a baseball game. Would you rather face a pitch with smaller curvature or smaller break? Would you know the difference? In this talk we will derive a model for the path of a pitch based on actual data from MLB.com's Gameday™ feature. Using this model we will analyze the curvature and break of the pitch.

Shelley Leber, University of Dayton
Mean of Real Numbers
The mean of real numbers is not so average after all. In this talk, we will discuss the different types of means and how they are interrelated. We will begin with the idea of a mean pertaining to two real numbers. In the end, we will be able to find means involving more than two numbers.

Jenita Levine, University of Dayton
Who Has All the Gold Coins?
A sack of gold coins is stolen by a gang of nine thieves. If each thief gets an equal share of the coins, then two coins remain. If one thief is caught before the coins are divided so that each of the others get an equal share, then one coin remains. If two of the thieves are caught before the coins are divided, then each thief gets an equal share. Find the smallest number of coins in the sack. This problem will be solved using linear congruences and the Chinese Remainder Theorem.

Kerry McIver, John Carroll University
The Perfect Shuffle
We will demonstrate two different methods to determine how many riffles are required to obtain the perfect shuffle using various sized decks.

Jeffrey Neugebauer, University of Dayton
Boundedness Properties of Solutions of Nonlinear Volterra Integral Equations
Nonlinear Volterra integral equations are studied using the contraction mapping principle as the primary mathematical tool. In particular, the existence of bounded solutions of these equations are found using various boundedness assumptions on *a(t)* and *a'(t).*

Philip Pfeiffer*, Sudhindra Gadagkar and Peter Hovey, University of Dayton
Determining the Statistical Significance of Observed Frequencies of Short DNA Motifs in a Genome
Until recently over 90 percent of the DNA in the human genome was considered junk DNA having no known function. However, this non-coding DNA is now known to harbor elements that perform important functions in gene regulation. In particular, there is currently much interest in the search for short DNA motifs collectively known as cis-regulatory elements. Most studies attempt to identify these elements by means of cross-species comparisons. We have approached the problem of finding cis-regulatory elements by searching for conserved DNA motifs within genomes. This requires searching for DNA motifs that are repeated in the genomes either more or less frequently than expected by random chance. However, the statistical significance of any observed frequency cannot be determined by the usual chi-squared test since overlapping regions of the genome are checked for DNA motif matches. We have developed a statistical measure to quantify the expectation and variance of the frequency of a given DNA motif in a given target sequence.

Harrison Potter, Marietta College
Pricing the Asian Call Option
Stochastic calculus is applied to pricing a specific option, known as the Asian call option, that arises in financial applications of probability theory. By modeling the asset price as a geometric Brownian motion, the risk-neutral conditional expectation representation of the option price is simplified to a double integral involving an implicitly defined joint density function. An approximation is then made that enables the exact price of a closely related option to be calculated more explicitly. This latter result is strikingly similar to the Black-Scholes-Merton formula. Robert Merton and Myron Scholes won the 1997 Nobel Prize in Economics for this work, which serves as a model for our approach to pricing the Asian call option.

Anne Rollick*, John Carroll University, and Jessica Flores, Kimberly Jones, James Weigandt,
The Mordell-Weil Group of the Elliptic Curves $y^2 = (1-x^2)(1-k^2x^2)$.
We will define elliptic curves, their ranks, and rational points and give several important theorems. We will then look at the current rank records and some results pertaining to curves of high rank.

Shawn Ryan, University of Akron
A Buckling Problem for Graphene Sheets
We develop a continuum model that describes the elastic bending of a graphene sheet, which is a hexagonal lattice of carbon atoms. The sheet interacts with a rigid substrate by van der Waals forces. After describing basic ideas about buckling and stability, we present a buckling problem for the graphene sheet perpendicular to the substrate. After identifying a branch of vertical solutions, we discuss the stability of solutions on this branch. Also presented are the results of atomistic simulations. The simulations agree qualitatively with the predictions of our continuum model but also suggest the importance, for some problems, of developing a continuum description of the van der Waals interaction that incorporates information on atomic positions.

Erin Shafer, University of Dayton
Property Distributions and Blending Predictions of JP-8 Fuel
We will provide a background on plans to blend JP-8 fuel with synthetic FT fuel to produce cleaner fuels. We will discuss the distribution of the different properties of JP-8 in the five regions of the United States over the past six years. Using these distributions, we will determine if the properties of JP-8 fuel can be predicted for future years to determine the maximum amount of FT fuel that can be safely blended with the JP-8 fuel.

Jinyang Sun, University of Dayton
A Basic Building Block in Life Insurance--Time-Until-Death Random Variable ***T(x)***
A basic problem in insurance is to determine the premium. To solve it, the basic building block in life insurance, time-until-death random variable *T(x),*will be introduced. How to determine its distribution by life table will be discussed and presented. It will be shown by examples how to use this random variable to solve premium problems for life contingency insurance products.

Edward Timko, University of Dayton
Conditional Convergence of Integrals in Analogy to Series

The conditional convergence of the series $\sum_{j=1}^{\infty} f(j)$ motivates the study of the improper integral $\int_1^{\infty} \frac{(-1)^x}{x} dx$. In particular, the improper integral $\int_1^{\infty} \frac{(-1)^x}{x} dx$ is defined, analyzed, and a process analogous to rearrangement of terms for conditionally convergent series is described. For example, given $z \in C$, we shall construct a so-called rearrangement of the integral such that $z = \int_1^{\infty} f(x)dx$.

Victor Velten, University of Dayton
The Mathematics Behind the Finite Element Method

The finite element method is used in a variety of simulations today. Also named the finite volume method, it is a discretization technique that seeks to divide a finite volume into discrete parts and solve the problem over all of the pieces. This method ascribes to the idea that the whole is the sum of the parts. In the presentation the basics and underlying theory surrounding the finite element method are explored and then the method is applied to a basic Poisson problem, a problem that has applications in electrostatics and various potential fields. This talk assumes knowledge of the concepts of partial derivatives, the gradient operator, and basic vector operations.

Kevin Ventullo, Illinois Institute of Technology
Silver Cubes

Let K_n be a complete graph of order n. Let * denote a Cartesian product. Let I be a maximum independent set in $K_n*K_n*K_n$. A silver cube then is a coloring of all vertices (using 3n-2 colors) in $K_n*K_n*K_n$ such that the closed neighborhood of every vertex in I contains every color precisely once. The problem can be restated visually in a somewhat friendlier way, bearing a slight resemblance to a sudoku puzzle. If two cubes of size a and b exist, then a cube of size ab is constructible. It is an open question whether any silver cubes exist besides those where $n = 2^3 3^4 5^3 7^1$. The factor 7 was discovered this past summer using a method that will be presented in the talk.

Brandon Weislak, Xavier University
Euler: Harmonious Mathematics

Euler outlined a "new music theory" in his lengthy Tentamen novae theoriae musicae. This paper proposes to examine the fundamentals of Euler's theory, and locate similar ideas in the theories of other musically minded mathematicians such as d'Alembert, Descartes, Mersenne, and even the musical theories of the ancient Greeks. Finally, we bring to light the legacy of such an important work on music by situating the work in the context of modern music theory.

Emily Wheeler, University of Dayton
The Connection Between Similarity and Right Triangle Trigonometry

This talk begins with a statement of the definition of triangle similarity, followed by the Angle-Angle-Angle (AAA) postulate for determining similarity. Next, we provide a proof of an important property of proportions, which leads to a discussion of the relationship between right triangle similarity and the trigonometric functions of sine, cosine and tangent for acute angles.

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